Variable Names & Descriptions

NASA Carbon Airborne Flux Experiment (CARAFE) Airborne 2016 and 2017 Campaigns

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The tables below provide the variable information, example file names, and associated notes for data file. Select notes are provided. Additional notes are available in the header of the files.

Generally, the data files are named CARAFE-<dataID>_SHERPA_<date>_<revision>_<launch>.<extension>, where

<dataID> = short description of measured parameter/species, instrument, or model preceded by the mission name "CARAFE-" (DLH, FLUX, GHG-1Hz, GHG-10Hz, MET, or WINDS)
<locationID> = short description of site, station, platform, laboratory, or institute (SHERPA, or SONDES)
<date> = four-digit year (2016 or 2017), two-digit month (05 or 09), two-digit day; the date always refers to the UTC date of launch
<revision> = revision number of data (e.g., R0, R1)
<launch> = optional launch number (L1, L2)
<comments> = optional additional information (10Hz, or 20Hz)
<extension> = file extension (*.ict or *.rtso)

DLH Files

File Name Format: CARAFE-DLH_SHERPA_<date>_<revision>_<launch>_<comments>.ict
Example File Name: CARAFE-DLH_SHERPA_20160907_R0.ict
Notes
INSTRUMENT_INFO: Diode Laser Hygrometer measurements of H2O vapor
DATA_INFO: Water Vapor Volumetric Mixing Ratio in ppmv: p(H2O) / p(ambient) * 10^6. Relative humidities are calculated from DLH mixing ratio, project static pressure, and project static temperature and are provided for convenience.
UNCERTAINTY: H2O(v) = 5%, RHi, RHw = 15%

Variable Name	Units/Format	Description
Start_UTC	time	Seconds since midnight UTC at start of sampling
H2O_ppmv	ppmv	Water vapor mixing ratio in parts per million volume
RHi_pct	%	Relative Humidity with respect to water ice
RHw_pct	%	Relative Humidity with respect to liquid water
PPS (20 Hz files only)		GPS pulse-per-second

FLUX Files

File Name Format: CARAFE-FLUX_SHERPA_<date>_<revision>_<launch>.ict **Example File Name:** CARAFE-FLUX_SHERPA_20160923_R3.ict

Notes

ASSOCIATED_DATA: Files used for flux calculations: CARAFE-GHG-10Hz_SHERPA_20160926_R1.ict, CARAFE-WINDS_SHERPA_20160926_R0.ict, CARAFE-DLH_SHERPA_20160926_R0_20Hz.ict. Spectra, cospectra, and other supporting data available upon request.

INSTRUMENT_INFO: See GHG, WINDS and DLH files.

DATA_INFO: Wavelet transforms applied to 10Hz observations over each leg. Cospectral power within the cone-of-influence is included in total flux. Resultant 10 Hz fluxes are bin-averaged to 1 Hz (~70-80m). Comparison with surface values requires multiplication by the provided divergence correction factors (F_div). Divergence corrections are from linear fits to vertical profiles of selected flux legs (see Special Comments). Surface extraploation is NOT recommended for any fluxes where a divergence correction is not provided. All fluxes and related quantities are corrected upwards by a factor of 1/0.76 for bias induced by vertical wind variance damping. ustar filtered for momentum flux qcoi<0.5. wstar and dx05 filtered for sensible heat flux qcoi<0.5.

UNCERTAINTY: Errors in each flux (F) is due to 1) random error (RE) due to turbulence (stochastic) and instrument noise, and 2) systematic error (SE) due to turbulence (long-wave), instrument response time, and accuracy. SE and RE are provided independently for each flux. Note that RE is given in flux units, and SE in fractional units. Total error is E = sqrt(RE^2 + (SE*F)^2). Individual error contributions are available upon request. When averaging fluxes, average errors are: SEavg = mean(SE), REavg = sqrt(sum(RE^2))/N, where N is # of points in the average. When applying divergence correction factors (F_div), random error in these factors (F_div_err) are added in fractional quadrature with RE and SE: Esurf = Fsurf*sqrt((F_div_err/F_div)^2 + (RE/F)^2 + SE^2). Fluxes can become spurious near leg edges due to the cone-of-influence. The F_qcoi quality flag should be used to filter out suspect fluxes. A maximum permissible qcoi of 0.6 or less is recommended. Special note: Additional RE arises from the systematic error correction for vertical wind variance damping. Added uncertainties for H (50 W/m^2), LE (110 W/m^2), FCO2 (7 umol/m^2/s) and FCH4 (50 nmol/m^2/s) are already included in RE variables.

Variable Name	Units/Format	Description
Mid_UTC	s	Seconds since midnight
Leg	none	Leg index
Lat	decimal degrees	GPS latitude
Lon	decimal degrees	GPS longitude
Alt	m	GPS altitude
Dist	m	Distance along leg
ustar	m/s	Friction velocity
wstar	m/s	Convective velocity scale
dx05	m	Footprint half-width
H	W/m^2	Sensible heat flux
LE_LGR	W/m^2	Latent heat flux from LGR
LE_DLH	W/m^2	Latent heat flux from DLH
FCO2	umol/m^2/s	CO2 flux

FCH4	nmol/m^2/s	CH4 flux
H_RE	W/m^2	Flux random error
LE_LGR_RE	W/m^2	Flux random error
LE_DLH_RE	W/m^2	Flux random error
FCO2_RE	umol/m^2/s	Flux random error
FCH4_RE	nmol/m^2/s	Flux random error
H_SE	none	Flux systematic error fraction
LE_LGR_SE	none	Flux systematic error fraction
LE_DLH_SE	none	Flux systematic error fraction
FCO2_SE	none	Flux systematic error fraction
FCH4_SE	none	Flux systematic error fraction
H_qcoi	none	Fraction of cospectral power within cone-of-influence
LE_LGR_qcoi	none	Fraction of cospectral power within cone-of-influence
LE_DLH_qcoi	none	Fraction of cospectral power within cone-of-influence
FCO2_qcoi	none	Fraction of cospectral power within cone-of-influence
FCH4_qcoi	none	Fraction of cospectral power within cone-of-influence
H_div	none	Flux divergence correction factor for surface extrapolation
LE_LGR_div	none	Flux divergence correction factor for surface extrapolation
LE_DLH_div	none	Flux divergence correction factor for surface extrapolation
FCO2_div	none	Flux divergence correction factor for surface extrapolation
FCH4_div	none	Flux divergence correction factor for surface extrapolation
H_div_err	none	Divergence correction factor uncertainty
LE_LGR_div_err	none	Divergence correction factor uncertainty
LE_DLH_div_err	none	Divergence correction factor uncertainty
FCO2_div_err	none	Divergence correction factor uncertainty
FCH4_div_err	none	Divergence correction factor uncertainty
BLH	m	Boundary layer depth
u_std	m/s	Standard deviation of along-vector wind speed
v_std	m/s	Standard deviation of cross-vector horizontal wind speed
w_std	m/s	Standard deviation of vertical wind speed
Lobukhov	m	Obukhov length

GHG-1Hz Files

File Name Format: CARAFE-GHG-1Hz_SHERPA_<date>_<revision>_<launch>.ict
Example File Name: CARAFE-GHG-1Hz_SHERPA_20160916_R1.ict
Notes

INSTRUMENT_INFO: 10Hz LGR CH4/H2O, 10Hz LGR CO2, Slow Picarro CH4/CO2/H2O (G1301m @0.1Hz or G2401m @1Hz; see Special Comments). All instruments sampling from a common inlet. PAR: LICOR LI-190R.
DATA_INFO: Processing code available upon request. Major data reduction steps include: 1) Time correction for GPS offset. 2) LGR CH4/H2O corrections for ringdown time anomalies. 3) PIC CO2, CH4, H2O corrected for water dilution/broadening (G1301m only; see Chen et al., AMT (2010) and G1301m white paper). 4) PIC CO2 and CH4 calibrated by scaling to NOAA gas standard (G1301m only). 5) PIC CO2, CH4, H2O time-shifted to match 1Hz LGR data.6) LGR CO2 and CH4 corrected for water dilution/broadening (based on lab data). 7) LGR CO2, CH4, H2O linearly scaled to PIC measurements (fit uncertainty included in stated accuracy). 8) PAR data filtered for roll<5deg and corrected for aircraft attitude/heading.9) GPS data from GHG transceiver; may not be identical to that in Sherpa housekeeping files.10) All data bin-averaged to common 1Hz or 10Hz (LGRs only) time-base.
UNCERTAINTY: Accuracy + Precision (1-sigma at native sampling rate): PIC CO2: 0.015% + 0.05ppm. PIC CH4: 0.03% + 0.0004ppm. PIC H2O: 10% + 100ppm (not calibrated; accuracy estimated from comparison with DLH). LGR CO2: 0.065% + 1.050ppm. LGR CH4: 0.12% + 0.0065ppm. LGR H2O: 10% + 200pppm (not calibrated; accuracy estimated from comparison with DLH). PAR: 10% (precision unknown).

Variable Name	Units/Format	Description
Mid_UTC	s	Seconds since midnight
PIC_CO2_ppm	ppm	Picarro CO2 dry mole fraction
PIC_CH4_ppm	ppm	Picarro CH4 dry mole fraction
PIC_H2O_ppm	ppm	Picarro H2O dry mole fraction
LGR_CO2_ppm	ppm	LGR CO2 dry mole fraction
LGR_CH4_ppm	ppm	LGR CH4 dry mole fraction
LGR_H2O_ppm	ppm	LGR H2O dry mole fraction
PAR_umolm2s	umol/m^2/s	Downwelling photosynthetically-active radiation flux
Lat	decimal degrees	GPS latitude
Lon	decimal degrees	GPS longitude
Alt	m	GPS altitude

GHG-10Hz Files

File Name Format: CARAFE-GHG-10Hz_SHERPA_<date>_<revision>_<launch>.ict
Example File Name: CARAFE-GHG-10Hz_SHERPA_20160912_R1.ict
Notes
INSTRUMENT_INFO: 10Hz LGR CH4/H2O, 10Hz LGR CO2, Slow Picarro CH4/CO2/H2O (G1301m @0.1Hz or G2401m @1Hz; see Special Comments). All instruments sampling from a common inlet. PAR: LICOR LI-190R.
DATA_INFO: Processing code available upon request. Major data reduction steps include: 1) Time correction for GPS offset. 2) LGR CH4/H2O corrections for ringdown time anomalies. 3) PIC CO2, CH4, H2O corrected for water dilution/broadening (G1301m only; see Chen et al., AMT (2010) and G1301m white paper). 4) PIC CO2 and CH4 calibrated by scaling to NOAA gas

standard (G1301m only). 5) PIC CO2, CH4, H2O time-shifted to match 1Hz LGR data.6) LGR CO2 and CH4 corrected for water dilution/broadening (based on lab data). 7) LGR CO2, CH4, H2O linearly scaled to PIC measurements (fit uncertainty included in stated accuracy). 8) PAR data filtered for roll<5deg and corrected for aircraft attitude/heading.9) GPS data from GHG transceiver; may not be identical to that in Sherpa housekeeping files.10) All data bin-averaged to common 1Hz or 10Hz (LGRs only) time-base.
UNCERTAINTY: Accuracy + Precision (1-sigma at native sampling rate): PIC CO2: 0.015% + 0.05ppm. PIC CH4: 0.03% + 0.0004ppm. PIC H2O: 10% + 100ppm (not calibrated; accuracy estimated from comparison with DLH). LGR CO2: 0.065% + 1.050ppm. LGR CH4: 0.12% + 0.0065ppm. LGR H2O: 10% + 200pppm (not calibrated; accuracy estimated from comparison with DLH). PAR: 10% (precision unknown).

Variable Name	Units/Format	Description
Mid_UTC	s	Seconds since midnight
LGR_CO2_ppm	ppm	LGR CO2 dry mole fraction
LGR_CH4_ppm	ppm	LGR CH4 dry mole fraction
LGR_H2O_ppm	ppm	LGR H2O dry mole fraction
PPS	logical	NASDAT Pulse-per-second

SONDES Files

File Name Format: CARAFE-MET_SONDES_<date>_R0.rtso
Example File Name: CARAFE-MET_SONDES_2016090718_R0.rtso
Notes
The companion file IDL_reader_for_sondes_rtso_files.pro is provided for data access using IDL software.
These files can also be opened in generic text software.

Variable Name	Units/Format	Description
error		0 if the file was read ok; an error code otherwise
time	s	the elapsed flight time, in seconds
pressure	mbar	the air pressure, in mbars
temperature	C	air temperature, in degrees Celsius
relhumidity	%	relative humidity, in percent
geopothgt	m	geopotential height, in m
dewpoint	C	dew point, in degrees Celsius
refractive_index		refractive index, in N Units
gradient_refractive_index	N km-1	gradient refractive index, in N / km
modified_refractive_index	M units	modified refractive index, in M Units
speed_of_sound	m s-1	speed of sound, in m/s
density	g m-3	air density, in grams per cubic meter
vapor_pressure	mbar	vapor pressure, in mbars
potential_temperature	C	potential temperature, in degrees Celsius

virtual_temperature	C	virtual temperature, in degrees Celsius
specific_humidity	g kg-1	specific humidity, in grams per kilogram
utc_time	s	UTC time, in seconds
wind_speed	m s-1	wind speed, in m/s
wind_direction	degrees	wind direction, in degrees azimuth
v_wind	m s-1	east/west wind component, unfiltered, in m/s
u_wind	m s-1	north/south wind component, unfiltered, in m/s
longitude	decimal degrees	longitude, in decimal degrees
latitude	decimal degrees	latitude, in decimal degrees
w_wnd	m s-1	vertical wind component, unfiltered, in m/s
altitude_gps	m	geometric height, in m
badvalue		the bad-or-missing fill-value for the data
header		a string array containing the file's header information
quiet		if set, then no messages will be printed when bad data lines are encountered in the input

WINDS Files

File Name Format: CARAFE-WINDS_SHERPA_<date>_<revision>_<launch>.ict
Example File Name: CARAFE-WINDS_Sherpa_20160924_R0.ict
Notes
INSTRUMENT_INFO: Flagged data are due to missing data or non straight and level flight
DATA_INFO: 3-D winds are valid for straight and level flight, take caution when using data in turns/ascents/descents; Horizontal winds are estimated based on a derived pressure corrected based on reverse headings, will be improved with time
UNCERTAINTY: all data are 5%

Variable Name	Units/Format	Description
UTC_mid	Secs after midnight	Time of acquisition
Latitude_deg	decimal degrees	Latitude measurement from the Applanix
Longitude_deg	decimal degrees	Longitude measurement from the Applanix
gpsALT_m	m	GPS Altitude measurement from the Applanix
Pitch_deg	degrees	Aircraft Pitch Angle measurement from the Applanix
Roll_deg	degrees	Aircraft Roll Angle measurement from the P-3B Applanix
TrueHead_deg	degrees	Aircraft True Heading from the Applanix
Pstat_mb	mb	Static Pressure (calculated)
TAS_ms-1	ms-1	True Air Speed (calculated)
Tstat_degC	degreesC	Static Air Temperature derived from the Total Air Temperature

u_ms-1	ms-1	East-West horizontal wind measurement in m/s
v_ms-1	ms-1	North-South horizontal wind measurement in m/s
w_ms-1	ms-1	Vertical wind measurement in m/s
WSPD_ms-1	ms-1	Wind speed in m/s
WDIR_deg	degrees	Wind Direction in deg